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(54) **TREATMENT DEVICE FOR FREE-FLOWING BULK MATERIAL**

(71) Applicant: **Wilhelm Schultheis**, Offenbach (DE)

(72) Inventor: **Wilhelm Schultheis**, Offenbach (DE)

(73) Assignee: **VIBRA MASCHINENFABRIK SCHULTHEIS GmbH & Co.**,
Offenbach (DE)

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See application file for complete search history.

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Primary Examiner — Gene Crawford

Assistant Examiner — Thomas Randazzo

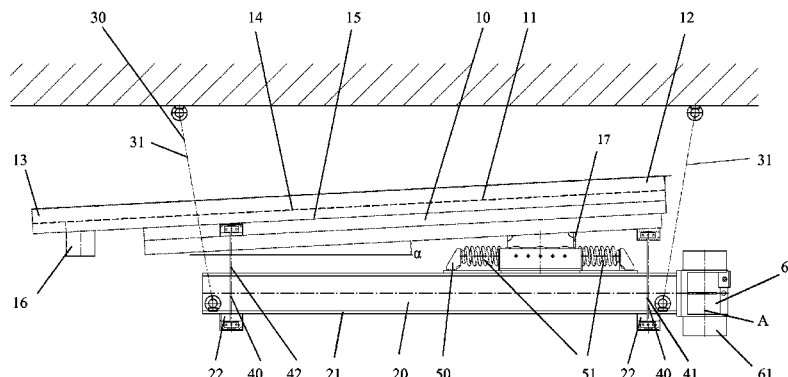
(74) *Attorney, Agent, or Firm* — Manfred Beck, P.A.

(57)

ABSTRACT

A treatment device for free-flowing bulk material includes a bulk material carrier with an inclined treatment area, a counter-vibration mechanism, which extends longitudinally under the bulk material carrier and runs horizontally or likewise in an inclined manner, a cable suspension for suspending the counter-vibration mechanism, supports for supporting the bulk material carrier in the vertical direction on the counter-vibration mechanism, a spring assembly with several springs connecting the bulk material carrier and the counter-vibration mechanism and providing an elastic support perpendicular to the vertical direction both in the longitudinal direction and in the transverse direction of the counter-vibration mechanism, and a vibration exciter for exciting the treatment area in the longitudinal and transverse direction of the counter-vibration mechanism. The treatment device is distinguished by a small constructional outlay and low maintenance requirements. Moreover, the risk of a contamination of the bulk material and the environment with lubricant is small.

11 Claims, 4 Drawing Sheets



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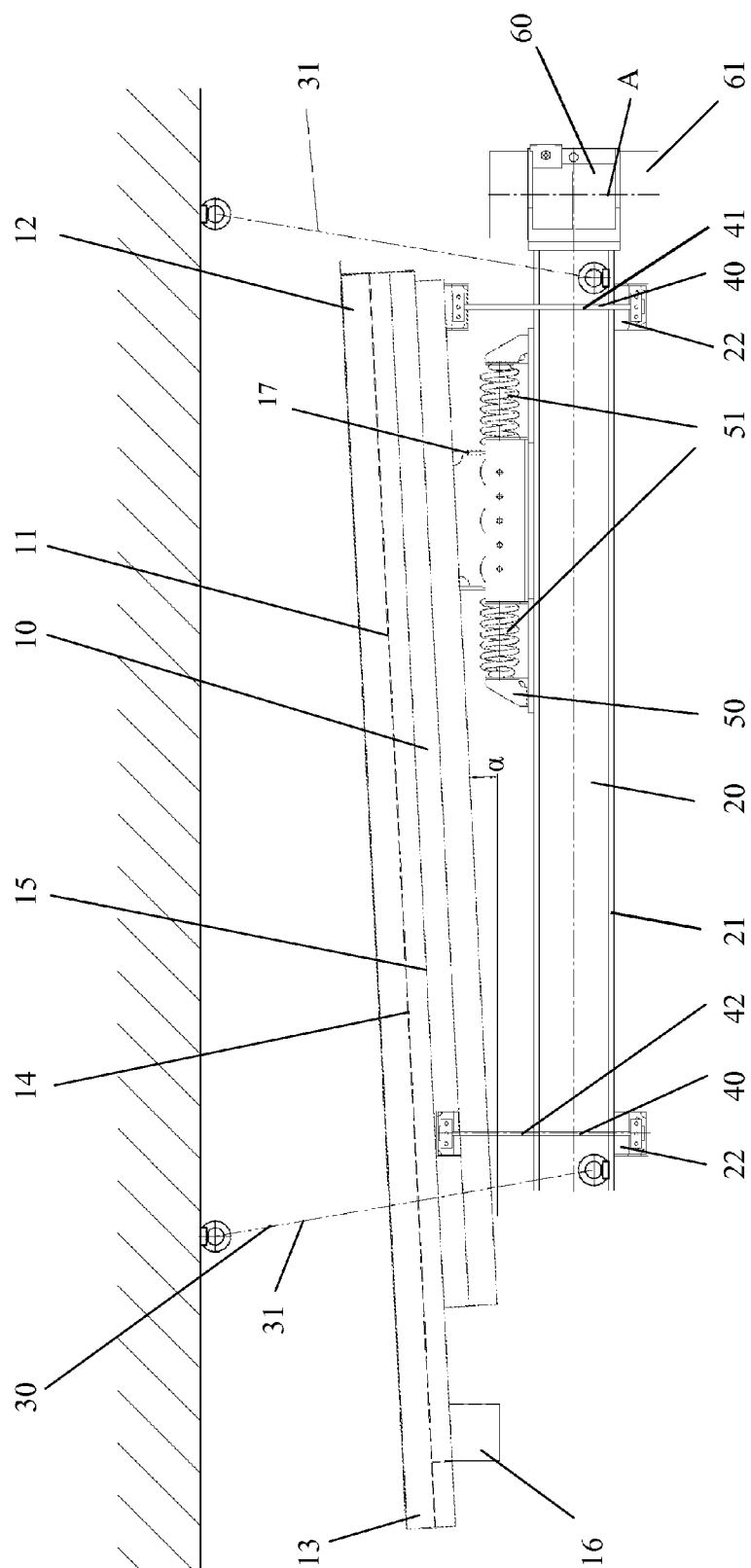


FIG. 1

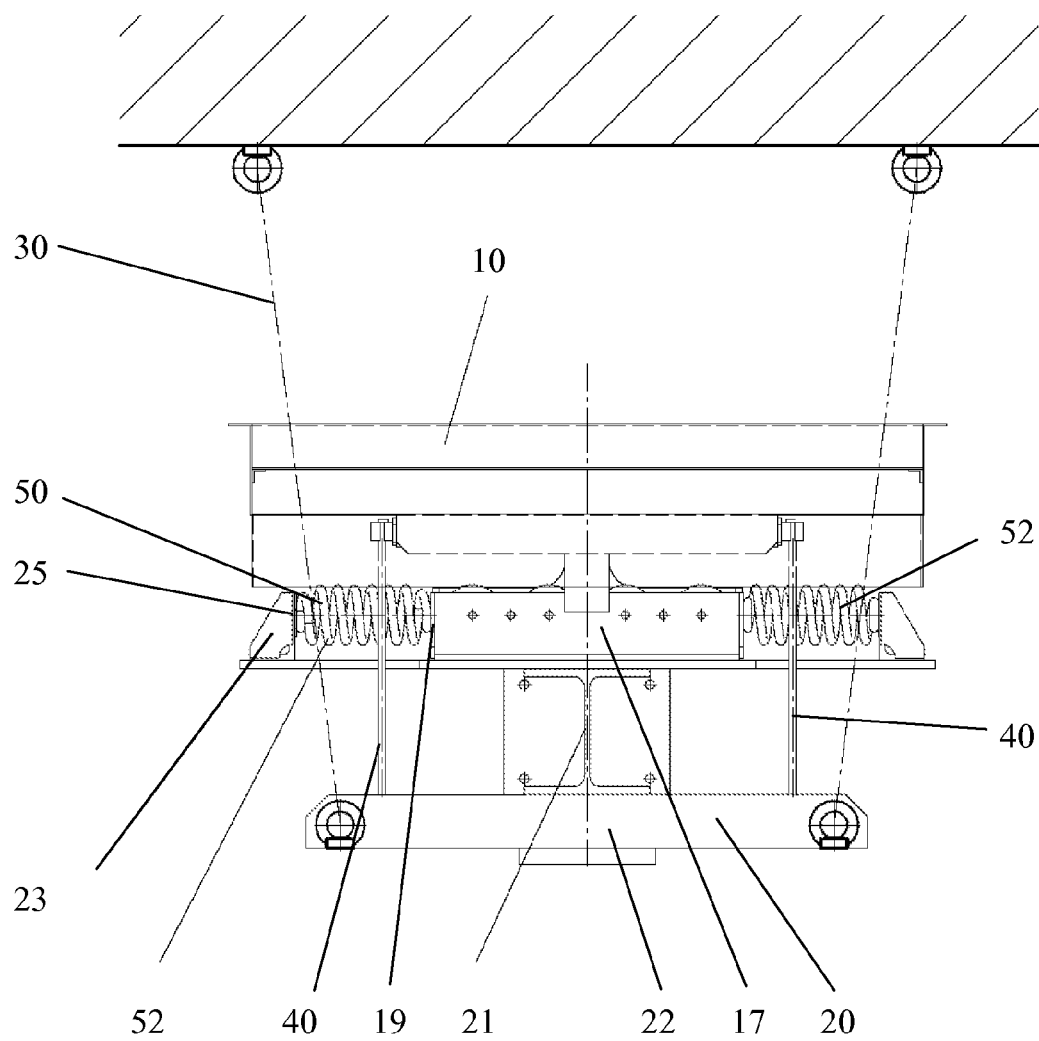


FIG. 2

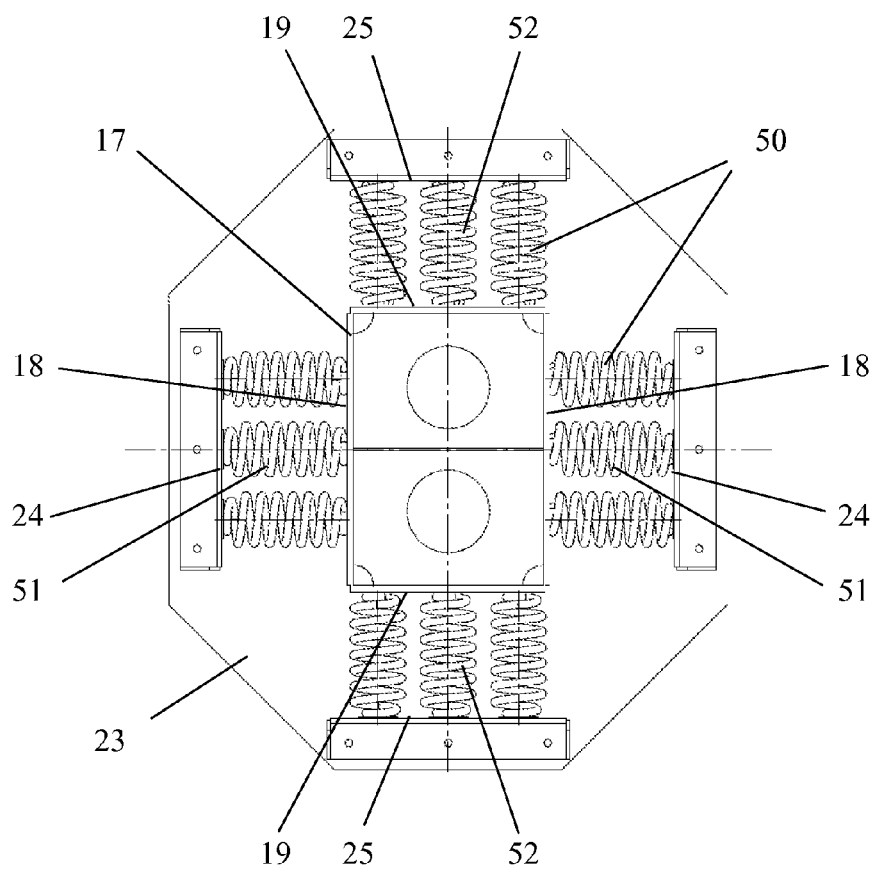


FIG. 3

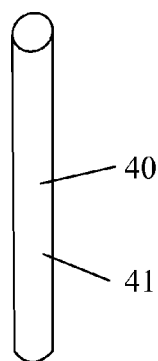


FIG. 4

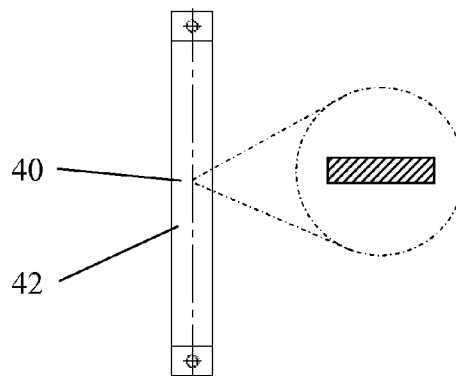


FIG. 5

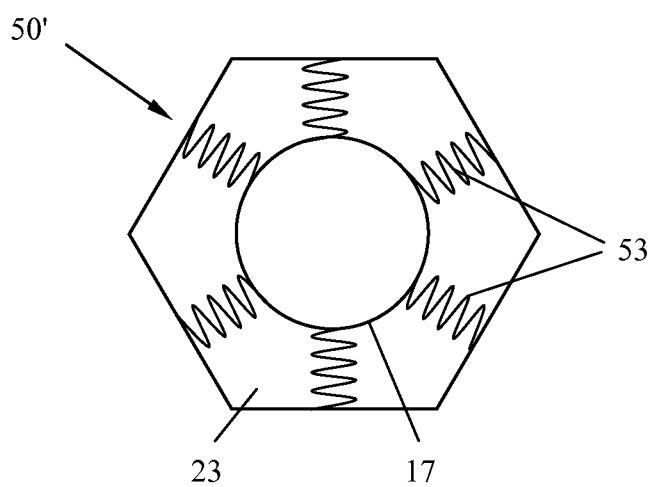


FIG. 6

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TREATMENT DEVICE FOR FREE-FLOWING BULK MATERIAL

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the priority, under 35 U.S.C. §119, of German Patent Application No. DE 10 2012 214 341.6, filed Aug. 10, 2012; the prior application is herewith incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

Field of the Invention

The invention relates to a treatment device for free-flowing bulk material including a bulk material carrier with an inclined treatment area, a counter-vibration mechanism which extends longitudinally under the bulk material carrier and runs horizontally, supports for supporting the bulk material carrier in the vertical direction on the counter-vibration frame, a cable suspension for suspending the counter-vibration mechanism on a supporting structure, and a vibration exciter for exciting the treatment area in the longitudinal and transverse direction of the counter-vibration mechanism.

Such treatment facilities are suitable, for example, for an effective screening of sensitive bulk materials in various grain-size fractions, but can also be used for other treatment tasks where the bulk material, due to gravity and supported by a vibration excitation, is transported across the inclined treatment area.

A treatment device of the type mentioned above in the form of a screening machine is for example described in European Patent Application No. EP 0 775 532 A1 as prior art. In the known screening machine, a drive motor is attached to the base frame for driving the bulk material carrier via a crank drive, such that the bulk material carrier is made to perform an essentially horizontal circular vibration motion at its head end at which also the feeding of bulk material occurs. The outlet-side end of the bulk material carrier is supported via slide plates on the base frame and is additionally connected to it by an articulated arm. The latter forces an elliptical vibration at the outlet-side end. Along the length of the bulk material carrier the vibration movement thus changes from the circular shape at the head end to a very flat ellipse at the outlet-side end. If necessary, also an almost linear vibration movement in the longitudinal direction can be achieved at the outlet-side end. This change of the vibration movement has a positive effect on the degree of separation of the screening.

In the case of the above-described screening machine there is however the problem that moving machine parts which require lubrication, such as the articulated arm and the crank drive, are next to or below the bulk material carrier, and can therefore cause a particularly in the food industry problematic contamination of the environment of the treatment area with lubricants.

In addition, the mounting and the gearing mechanism require a high constructional outlay and result in correspondingly high costs. Furthermore, the mounting of the bulk material carrier on the crank arm of the crank drive is not maintenance-friendly.

SUMMARY OF THE INVENTION

It is accordingly an object of the invention to provide a treatment device for free-flowing bulk material, which overcomes the above-mentioned disadvantages of the heretofore-

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known treatment devices of this general type and which reduces the constructional outlay of a treatment device of the aforementioned type as well as the risk of contamination of the bulk material with lubricant.

5 With the foregoing and other objects in view there is provided, in accordance with the invention, a treatment device for free-flowing bulk material, including:

a bulk material carrier with an inclined treatment area;

10 a counter-vibration mechanism extending longitudinally under the bulk material carrier and running horizontally or in an inclined manner;

a cable suspension configured for suspending the counter-vibration mechanism on a supporting structure;

15 supports for supporting the bulk material carrier in a vertical direction on the counter-vibration mechanism;

a vibration exciter for an excitation of the inclined treatment area in a longitudinal direction and a transverse direction of the counter-vibration mechanism;

a spring assembly having several springs; and

20 the bulk material carrier and the counter-vibration mechanism being connected by the spring assembly, the spring assembly providing an elastic coupling both in the longitudinal direction and in the transverse direction of the counter-vibration mechanism.

25 In other words, according to the invention there is provided a treatment device for free-flowing bulk material, including a bulk material carrier with an inclined treatment area, a counter-vibration mechanism, which extends longitudinally under the bulk material carrier and runs horizontally or likewise in an inclined manner, a cable suspension for suspending the counter-vibration mechanism on a supporting structure, supports for supporting the bulk material carrier in the vertical direction on the counter-vibration frame, a vibration exciter for the excitation of the treatment area in the longitudinal and transverse direction of the counter-vibration mechanism, wherein the bulk material carrier and the counter-vibration mechanism are connected by a spring assembly which has several springs and provides an elastic coupling both in the longitudinal direction and in the transverse direction of the counter-vibration mechanism.

40 Thus a ball bearing mounted articulated arm at the outlet-side end as well as a crank drive at the head end can be avoided. A considerable cost saving potential arises as a result of the simpler construction. Nevertheless, at the treatment area a similar vibration characteristic can be achieved in which a circular vibration at the head end becomes increasingly elliptical or even linear in the direction of the outlet-side end.

Moreover, the risk of a contamination of the environment of the bulk material carrier with lubricants is reduced.

Depending on the adjustment, among other things via the supports, other vibration behaviors along the transport path from the head end to the outlet-side end can also be implemented.

55 According to another feature of the invention, all or at least some of the supports are embodied as flexurally soft rods with a round cross-section.

According to yet another feature of the invention, the bulk material carrier has a head end for feeding bulk material and has an outlet-side end for discharging bulk material; and at least those of the supports that are closest to the outlet-side end are flexurally softer in the longitudinal direction of the counter-vibration mechanism than in the transverse direction of the counter-vibration mechanism.

65 According to a further feature of the invention, the vibration exciter is embodied as an unbalance motor and is coupled to the counter-vibration mechanism; and the unbalance motor

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has a rotation axis perpendicular to the longitudinal direction and the transverse direction of the counter-vibration mechanism.

According to another feature of the invention, the springs of the spring assembly are coil springs with respective horizontal lines of action.

According to another feature of the invention, the spring assembly has a first set of springs whose lines of action run in the longitudinal direction of the counter-vibration mechanism, and a second set of springs whose lines of action run in the transverse direction of the counter-vibration mechanism.

According to a further feature of the invention, the springs of the spring assembly are disposed in a star-shaped manner.

According to another feature of the invention, the treatment area is embodied as a screen.

Thus at least some of the supports can for example be embodied as flexurally soft rods with a round cross section. These allow large deflections of the bulk material carrier both in the transverse direction and in the longitudinal direction and thus favor correspondingly large amplitudes of circular and/or elliptical vibration movements of the treatment area. Maximum amplitudes are in the order of 25 to 50 millimeters. In particular, these supports can be equally flexurally soft in the transverse direction and the longitudinal direction.

According to a further advantageous embodiment, at least the supports closest to the outlet-side end are flexurally softer in the longitudinal direction of the counter-vibration mechanism than in the transverse direction thereof. Thus a vibration ellipse with a defined eccentricity can be enforced at the outlet-side end. Such supports can be implemented in a particularly simple manner as leaf springs, which are flexurally soft in the longitudinal direction, however, in the transverse direction, have a significantly greater stiffness.

In a further advantageous embodiment, the vibration exciter is configured as an unbalance motor and is coupled to the counter-vibration mechanism. Here, the unbalance motor has a rotation axis perpendicular to the longitudinal and transverse direction of the counter-vibration mechanism.

The unbalance motor can be coupled as a sealed structural unit solely to the counter-vibration mechanism and has no mechanical connection elements to the bulk material carrier or to other components. In this way, the risk of a contamination of the environment of the bulk material carrier with lubricants is further reduced.

Alternatively it is possible to couple such a vibration exciter only to the bulk material carrier, wherein also in this case no mechanical connection elements at all are provided to further components.

According to a further advantageous embodiment of the invention, the springs of the spring assembly are coil springs with a horizontal line of action. This allows a particularly stable, clean and maintenance-free coupling.

The spring assembly can for example have a first set of springs, whose lines of action run in the transverse direction of the counter-vibration mechanism, and a second set of springs, whose lines of action run in the longitudinal direction of the counter-vibration mechanism. This allows an easy assembly.

However, a different arrangement of the springs is also possible, as long as their entirety allows a coupling or, respectively, a connection both in the transverse direction as well as in the longitudinal direction. For example, it is also possible to arrange the springs of the spring assembly in a star-shaped manner.

As stated above, the treatment device can be operated as a screening machine, wherein the treatment area is then con-

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figured as a screen. However, the treatment device can also be used for other treatment tasks which are not necessarily associated with a screening.

Other features which are considered as characteristic for the invention are set forth in the appended claims.

Although the invention is illustrated and described herein as embodied in a treatment device for free-flowing bulk material, it is nevertheless not intended to be limited to the details shown, since various modifications and structural changes may be made therein without departing from the spirit of the invention and within the scope and range of equivalents of the claims.

The construction and method of operation of the invention, however, together with additional objects and advantages thereof will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic side elevational view of an embodiment of a treatment device according to the invention;

FIG. 2 is a diagrammatic elevational view toward the outlet-side front end of the treatment device according to FIG. 1;

FIG. 3 is a diagrammatic plan view of the spring assembly according to the invention;

FIG. 4 is a perspective detail view of a support with a round cross section in accordance with the invention;

FIG. 5 is a detail view of a support embodied as a leaf spring in accordance with the invention; and

FIG. 6 is a schematic representation of an alternative spring assembly in accordance with the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The embodiment illustrated in FIGS. 1 to 5 shows a treatment device for free-flowing bulk material using the example of a screening machine. It is especially suitable for the screening of sensitive screening materials into different grain-size fractions, in particular for the separation of powdery and granular particles from a mass flow consisting predominantly of granulates or agglomerates.

The treatment device can however also be employed for other treatment tasks which require a vibration excitation of the bulk material, which is to be conveyed, in an essentially horizontal or slightly inclined treatment plane.

The treatment device includes a bulk material carrier 10 with a treatment area 11 which, if the transport of the bulk material is to be primarily achieved by the force of gravity, is at least slightly inclined with respect to a horizontal plane. For most free-flowing bulk materials suitable inclination angles α are in the order of 0° to 20°, preferably from 1.0° to 10°.

The treatment area 11 extends in this case from a head end 12 of the preferably oblong bulk material carrier 10, at which the feeding of bulk material occurs, to an outlet-side end 13, at which the bulk material leaves the bulk material carrier 10 again after passing through the treatment area 11. In the case of screening machines, the bulk material carrier 10 is also referred to as a screening box.

In the illustrated exemplary embodiment, the treatment area 11 is embodied as a screen 14, so that at the outlet side two mass flows are delivered, namely, the screened fraction, which is guided via a pan 15 of the bulk material carrier 10, that runs below the screen 14, to an outlet 16, and the residual fraction, which in this case is discharged via the outlet-side front end.

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A counter-vibration mechanism **20** extends longitudinally below the bulk material carrier **10**. The counter-vibration mechanism **20** runs horizontally in its longitudinal direction. It is suspended via a cable suspension **30** on a supporting structure. The supporting structure can for example be a frame construction, which is installed at the installation location of the treatment device. But it can also be a part of a building. In the present case a cable suspension **30** with four cables **31** is shown, wherein the cables **31** are coupled to end sections of the counter-vibration mechanism **20** that are spaced apart from one another in the longitudinal direction. However, a larger number of cables can also be provided in particular in the case of longer treatment devices. Via the cable suspension **30** a very good decoupling between the treatment device and the supporting structure is achieved. In particular a transmission of reaction forces in the longitudinal direction and the horizontal transverse direction of the counter-vibration mechanism **20** is avoided. The dynamic vertical forces, however, are small, because the vibration excitation takes place in a horizontal plane defined by the longitudinal and transverse direction of the counter-vibration mechanism **20**.

In a modification of the exemplary embodiment, the counter-vibration mechanism **20** can be somewhat inclined with respect to the horizontal such that its longitudinal direction then does not run horizontally. The longitudinal direction of the counter-vibration mechanism **20** can in particular have the same inclination as the treatment area **11**.

In the illustrated exemplary embodiment, the counter-vibration mechanism **20** is formed by a solid double-T beam **21** at whose ends cross-braces **22** for connecting the cables **31** are attached. However, the counter-vibration mechanism **20** can also be embodied in other ways, for example in the form of a closed frame.

The bulk material carrier **10** is supported on the counter-vibration frame **20** in the vertical direction via supports **40** and, except via the springs **53** or, respectively, the sets of springs **51**, **52**, is otherwise not connected to the supporting structure. The supports **40** are embodied as flexurally soft rods or bars which extend in the vertical direction, so that the bulk material carrier **10** is mounted in a floating manner and can freely vibrate perpendicular to the vertical direction both in the longitudinal direction and in the transverse direction.

According to the invention, the transition from an initially circular to an elliptical vibration movement is in principle achieved with partial resonance vibration systems of similar frequency in the longitudinal and transverse direction with springs **53** or sets of springs **51**, **52** as well as a positioning of the transverse vibration system in the first third of the bulk material carrier.

At least some of the supports **40** are embodied as flexurally soft rods **41** with a round cross section, as is illustrated in FIG. **4**. These are equally flexible in the longitudinal and transverse direction and allow at the treatment area **11** maximum movement amplitudes in the longitudinal direction and transverse direction of up to about 100 mm. This makes it possible to achieve the circular vibration movement which is impressed by the partial resonance vibration systems in the longitudinal and transverse direction with springs **53** or sets of springs **51**, **52** and their positioning in the first third of the bulk material carrier. If one restricts the elasticity of the supports **40** in a direction, then this is equivalent to a reduction of the maximum vibration amplitudes in the respective direction. In this way the shape of the ellipse at the outlet-side end **13** can be influenced in a targeted manner. If the elliptical vibration movement is to be implemented for example from an initially circular vibration movement to a flatter elliptical vibration

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movement, the supports **40** closest to the outlet-side end **13** can be made flexurally softer in one direction, for example in the longitudinal direction of the counter-vibration mechanism **20** than in the transverse direction thereof. FIG. **5** shows only in an exemplary manner correspondingly suitable supports **40** in the form of leaf springs **42** with a rectangular cross section.

Furthermore, the bulk material carrier **10** and the counter-vibration mechanism **20** are connected by a spring assembly **50** having several springs. The spring assembly **50** achieves an elastic support perpendicular to the vertical direction both in the longitudinal direction and in the transverse direction of the counter-vibration mechanism **20**. A support in the vertical direction is not provided at this location.

The spring assembly **50** is disposed near the head end **12** between the bulk material carrier **10** and the counter-vibration mechanism **20**. It is preferably disposed, in relation to the longitudinal extension of the bulk material carrier **10**, below the half of the bulk material carrier **10** that includes the head end **12**, preferably the third of the bulk material carrier **10** that includes the head end **12**.

In the illustrated exemplary embodiment, the springs of the spring assembly **50** according to FIG. **3** are coil springs **51** and **52** with a horizontal line of action. These springs are divided into a first set of springs **51**, whose lines of action run in the longitudinal direction of the counter-vibration mechanism **20**, and a second set of springs **52**, whose lines of action run in the transverse direction of the counter-vibration mechanism **20**. At the bottom side of the bulk material carrier **10** there is a box-shaped projection **17** whose side walls **18** and **19**, which point in the longitudinal and transverse direction, form support surfaces for the coil springs **51** and **52**. A console **23** is provided, in particular attached or formed, at the counter-vibration mechanism **20** wherein the console **23** has corresponding support surfaces **24** and **25** for the coil springs **51** and **52**. The coil springs **51** and **52** are thus in each case accommodated between a support surface **18** or, respectively, **19** of the bulk material carrier **10** and a support surface **24** or, respectively, **25** of the counter-vibration mechanism **20**.

It is possible to deviate from the spatial arrangement of the springs illustrated in FIG. **3** as long as it is ensured that an elastic support of the bulk material carrier **10** on the counter-vibration mechanism **20** perpendicular to the vertical direction in both the longitudinal direction and in the transverse direction of the counter-vibration mechanism **20** is provided.

For example, it is possible, as illustrated in FIG. **6**, to arrange the springs **53** of the spring assembly **50'** in a star-shaped manner.

If the counter-vibration mechanism **20** is mounted slightly inclined, the elastic support or, respectively, coupling can be carried out in a plane, which is parallel to a plane defined by the inclined longitudinal direction and the horizontal transverse direction of the counter-vibration mechanism **20**. Further, the elastic support or, respectively, coupling can also be effected in a plane parallel to the treatment area, in fact irrespective of whether the counter-vibration mechanism **20** is mounted horizontally or slightly inclined.

Lastly, the treatment device includes a vibration exciter **60** for the excitation of the treatment area **11** in the longitudinal and transverse direction of the counter-vibration mechanism **20**.

In the illustrated exemplary embodiment, the vibration exciter **60** is embodied as an unbalance motor **61** and is coupled to the counter-vibration mechanism **20**. The coupling can in this case be effected on the side of the head end **12**, as is illustrated in FIG. **1**. However, a space-saving coupling is also possible at the opposite end of the counter-vibration

mechanism **20**. In principle, however, the vibration exciter **60** can be connected at any point at the counter-vibration mechanism **20**. In this case however there arises no circular vibration at the inlet-side end.

In all cases, the vibration exciter **60** has a rotation axis A which is perpendicular to the longitudinal and transverse direction of the counter-vibration mechanism **20** and around which an unbalance rotates. The vibration exciter **60** or, respectively, unbalance motor **61** is solely and exclusively coupled to the counter-vibration mechanism **20** and has no mechanical connection elements whatsoever to the bulk material carrier **10** and to other components of the treatment device and of the supporting structure. The vibration exciter **60** or, respectively, unbalance motor **61** can thus be provided as a sealed structural unit, so as to counter the risk of a contamination of the environment of the bulk material carrier with lubricants.

In accordance with a modification of the illustrated exemplary embodiment, it is also possible to couple such a vibration exciter **60** or, respectively, sealed unbalance motor **61** only to the bulk material carrier **10** wherein in this case no mechanical connection elements to other components are provided at all.

Furthermore it is possible to dispose the vibration exciter **60** in such a way that its rotation axis A is perpendicular to the treatment area. If the counter-vibration mechanism **20** is inclined, the rotation axis A of the vibration exciter **60** can be aligned with the vertical or alternatively perpendicular to the plane defined by the longitudinal and transverse axis of the counter-vibration mechanism **20**.

The above-described treatment device forms a two-mass vibration system wherein the bulk material carrier **10** and the counter-vibration mechanism **20** are attuned to one another with the help of the spring assembly **50** such that both in the longitudinal direction and in the transverse direction of the counter-vibration mechanism partial resonance systems arise whose natural frequencies are the same or are at least approximately the same. In the case of the rotation of the vibration exciter **60** or, respectively, of the unbalance motor **61** close to these natural frequencies, the treatment device can be excited to vibrate such that along the length of the treatment area **11** the vibration movement changes from a circular shape to a very flat ellipse lying in the longitudinal direction, if applicable also to a purely linear reciprocating movement. A high degree of separation of the screening at a screening machine is for example hereby achieved.

By avoiding open rotating mechanical elements such as bearings, joints and gearing mechanisms, the risk of a contamination of the environment of the bulk material or of the bulk material itself with lubricant is reduced.

In addition, this results in a comparatively simple and thus cost-effective setup for which furthermore all relevant components are easily accessible for maintenance purposes.

The invention has been described in detail with reference to an exemplary embodiment as well as further modifications. However, it is not limited thereto but comprises all embodiments defined by the claims. In particular, described technical features can even then be combined with one another when this is not explicitly described, as long as this is technically possible.

What is claimed is:

1. A treatment device for free-flowing bulk material, comprising:
 - a bulk material carrier with an inclined treatment area;
 - a counter-vibration mechanism extending longitudinally under said bulk material carrier and running horizontally or in an inclined manner;
 - a cable suspension configured for suspending said counter-vibration mechanism on a supporting structure;
 - supports for supporting said bulk material carrier in a vertical direction on said counter-vibration mechanism;
 - a vibration exciter configured and arranged to provide an excitation of said inclined treatment area in a longitudinal direction and a transverse direction of said counter-vibration mechanism;
 - a spring assembly having several coil springs, each of said coil springs having a respective line of action extending horizontally or in an inclined manner; and
 - said bulk material carrier and said counter-vibration mechanism being connected by said spring assembly, said spring assembly providing an elastic coupling via said coil springs both in the longitudinal direction and in the transverse direction of said counter-vibration mechanism.
2. The treatment device according to claim 1, wherein at least some of said supports are embodied as flexurally soft rods with a round cross-section.
3. The treatment device according to claim 1, wherein:
 - said bulk material carrier has a head end for feeding bulk material and has an outlet-side end for discharging bulk material; and
 - at least those of said supports that are closest to said outlet-side end are flexurally softer in the longitudinal direction of said counter-vibration mechanism than in the transverse direction of said counter-vibration mechanism.
4. The treatment device according to claim 1, wherein:
 - said vibration exciter is embodied as an unbalance motor and is coupled to said counter-vibration mechanism; and
 - said unbalance motor has a rotation axis perpendicular to the longitudinal direction and the transverse direction of said counter-vibration mechanism.
5. The treatment device according to claim 1, wherein said coil springs have respective horizontal lines of action.
6. The treatment device according to claim 1, wherein said coil springs include a first set of coil springs whose lines of action run in the longitudinal direction of said counter-vibration mechanism, and a second set of coil springs whose lines of action run in the transverse direction of said counter-vibration mechanism.
7. The treatment device according to claim 1, wherein said coil springs of said spring assembly are disposed in a star-shaped manner.
8. The treatment device according to claim 1, wherein said treatment area is embodied as a screen.
9. The treatment device according to claim 1, wherein said vibration exciter provides a vibration excitation in a horizontal plane defined by the longitudinal direction and the transverse direction of said counter-vibration mechanism.
10. The treatment device according to claim 1, wherein said vibration exciter is solely coupled to said counter-vibration mechanism.
11. The treatment device according to claim 10, wherein said vibration exciter forms a sealed structural unit.

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